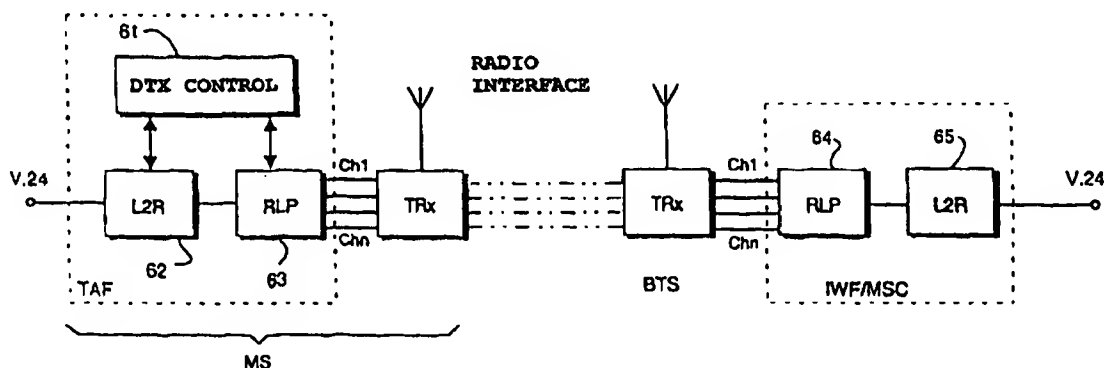




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : <b>H04J 3/16</b>		A1	(11) International Publication Number: <b>WO 97/23073</b>
			(43) International Publication Date: 26 June 1997 (26.06.97)
(21) International Application Number: PCT/FI96/00669 (22) International Filing Date: 17 December 1996 (17.12.96) (30) Priority Data: 956087 18 December 1995 (18.12.95) FI (71) Applicant (for all designated States except US): NOKIA TELECOMMUNICATIONS OY [FI/FI]; Upseerinkatu 1, FIN-02600 Espoo (FI). (72) Inventors; and (75) Inventors/Applicants (for US only): KANERVA, Mikko [FI/FI]; Kaarnatie 1 F 58, FIN-00410 Helsinki (FI). RÄSÄNEN, Juha [FI/FI]; Pensaskertuntie 8A, FIN-02660 Espoo (FI). JOKINEN, Harri [FI/FI]; Vähähiidentie 450, FIN-25370 Hiisi (FI). (74) Agent: OY KOLSTER AB; Iso Roobertinkatu 23, P.O. Box 148, FIN-00121 Helsinki (FI).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.	

(54) Title: MULTICHANNEL HIGH-SPEED DATA TRANSFER



## (57) Abstract

A digital mobile communication system has a high-speed non-transparent data connection between a transmitting and a receiving party (MS, TAF). For the data connection, parallel subchannels (ch1-chn), corresponding in number to the nominal data transfer rate, have been allocated on the radio interface. A radio link protocol (RLP) is responsible for transmitting data over the radio interface, and for acknowledging correct data frames and for retransmitting defective data frames. A transmission buffer (63) buffers the data frames to be transmitted and stores the data frames transmitted until it receives an acknowledgement of successful reception. In order to reduce interference and power consumption, user data is transmitted by using as many of the allocated subchannels as required by the actual user data rate at any one time. On the other allocated subchannels, transmission is interrupted or discontinuous transmission is activated.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgyzstan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	KZ	Kazakhstan	SG	Singapore
CH	Switzerland	LJ	Liechtenstein	SI	Slovenia
CI	Côte d'Ivoire	LK	Sri Lanka	SK	Slovakia
CM	Cameroon	LR	Liberia	SN	Senegal
CN	China	LT	Lithuania	SZ	Swaziland
CS	Czechoslovakia	LU	Luxembourg	TD	Chad
CZ	Czech Republic	LV	Latvia	TG	Togo
DE	Germany	MC	Monaco	TJ	Tajikistan
DK	Denmark	MD	Republic of Moldova	TT	Trinidad and Tobago
EE	Estonia	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	UG	Uganda
FI	Finland	MN	Mongolia	US	United States of America
FR	France	MR	Mauritania	UZ	Uzbekistan
GA	Gabon			VN	Viet Nam

## Multichannel high-speed data transfer

### Field of the Invention

The present invention relates to high-speed  
5 multichannel data services (HSCSD) on a radio interface of  
a mobile communication system.

### Background of the Invention

In mobile telecommunication systems of the time  
division multiple access (TDMA) type, time-division  
10 communication takes place on the radio path in successive  
TDMA frames, each of which consists of several time slots.  
In each time slot, a short information packet is sent as a  
radio frequency burst which has a finite duration and  
which consists of a set of modulated bits. The time slots  
15 are mainly used for transmitting control channels and  
traffic channels. On the traffic channels, speech and data  
are transmitted. On the control channels, signalling  
between a base station and mobile subscriber stations is  
carried out. An example of a TDMA radio system is the Pan-  
20 European mobile communication system GSM (Global System  
for Mobile Communications).

In conventional TDMA systems, each mobile station  
is assigned one traffic channel for data or speech  
transmission. Thus, the GSM system, for instance, may have  
25 up to eight parallel connections to different mobile  
stations on a same carrier wave. The maximum data transfer  
rate on one traffic channel is restricted to a relatively  
low level according to the available bandwidth and the  
channel coding and error correction used in the  
30 transmission, for example in the GSM system to 12 kbit/s,  
6 kbit/s or 3.6 kbit/s.

A digital mobile communication system typically  
uses several connection types which can be divided into  
two categories: transparent and non-transparent  
35 connections. On a transparent connection, data is

transferred through a traffic channel of the mobile communication system in a transparent way, which means that error correction on the radio path is carried out by employing channel coding only. In the GSM system the channel coding is Forward Error Correction (FEC). A non-transparent connection uses, in addition to channel coding, an additional protocol in which the data transmission over the traffic channel is repeated in case the data was not received correctly at the other end. In the GSM system, this communication protocol is Radio Link Protocol (RLP), used between a terminal adaptor of a mobile station MS and an interworking function IWF, which is typically at a mobile services switching center MSC. The RLP is a balanced (HDLC type) data transfer protocol having a frame structure. Error correction by the RLP is based on retransmission of frames corrupted on the traffic channel. There is another protocol, Layer 2 Relay (L2R), above the RLP. In the present patent application, the functional part of the TAF or IWF carrying out these protocols is referred to as an L2R/RLP unit.

In a normal data transfer state, the L2R/RLP unit packs user data into 200-bit long protocol data units (PDU), which are transmitted in 240-bit RLP frames over the radio interface to a second L2R/RLP unit. If there is no data or other information to be transferred between the two L2R/RLP units, discontinuous transmission (DTX) may be applied. DTX refers to a method reducing transmission on the radio path to a minimum (i.e. interrupt the transmission) during pauses in the data transfer. The aim is to reduce the power consumption of the transmitter, a very significant matter for the mobile stations, as well as the overall interference level on the radio path, which has an effect on the system capacity. The DTX operates independently for the uplink and downlink directions. The mobile communication network may either allow or prohibit

the use of DTX.

In normal L2R/RLP operation, the PDUs are possibly filled only partially, because the application may limit the maximum user rate below the maximum rate on a traffic channel. The PDUs may be full if the actual user data rate on the terminal interface is high enough or if, due to delays caused by re-transmission or some other congestion, the L2R/RLP buffer has enough user data to fill one PDU completely. It is also possible, depending on the implementation, to prefer full PDUs to partially full PDUs. This can be accomplished by using a timer or a counter to slightly delay the building of a PDU until there is enough data available (e.g. in a buffer) for a full PDU to be built, or until the building of a PDU, albeit only a partially full PDU, cannot be delayed any longer. The timer may have a typical value in the order of 20 ms, in other words the repetition period of TDMA frames. The timer value should be relatively short in order not to introduce additional data transmission delays.

However, the data rates of present-day mobile communication networks are not sufficient for the new, high-speed data services. A solution is proposed for introducing higher data rates for mobile communication systems in the applicant's co-pending PCT application WO95/31878, unpublished on the priority date of the present application: two or more parallel traffic channels (subchannels) are used on the radio path for one high-speed data connection. The high-speed data signal is distributed to the parallel subchannels at the transmitting end for the transmission over the radio path, and then combined at the receiving end. In this manner, it is possible to provide data transfer services which, depending on the number of allocated traffic channels, have a transfer rate up to 8 times the conventional data

rate. In the GSM system, for example, the total user data transfer rate 19.2 kbit/s is obtained with two parallel subchannels. This principle is also referred to as a multi-slot channel technique. High-speed data service thus  
5 obtained are referred to as HSCSD (High Speed Circuit Switched Data) services.

If the user data rate in a HSCSD service is lower than the maximum capacity of the radio link protocol, partially filled PDUs may be built and transmitted over  
10 the radio interface in the RLP frames. It is also possible that some subchannels carry full PDUs in their RLP frames and some subchannels occasionally carry partially full or empty PDUs in their RLP frames.

For the mobile station, this inefficient use of transmission capacity may lead to an unnecessarily high  
15 power consumption, heating of RF and other elements, and possibly a more complex scheduling of reception, transmission and neighbour cell monitoring than necessary for the actual user data rate.

For the radio interface, this leads to an increased  
20 interference, either in the uplink or the downlink direction, or both. For the base station and the IWF, reducing complexity is not that much of an issue as for the MS.

The prior art DTX implementation, and the slightly  
25 delayed building of PDUs can relieve the situation somewhat but not completely. The DTX is mainly used mainly in cases when there is nothing at all to be transmitted. When some data has to be transmitted (at a low rate), the  
30 transmission requiring only a fraction of the allocated bandwidth, the conventional DTX does not suffice.

#### **Disclosure of the Invention**

An object of the present invention is a  
35 discontinuous transmission suitable for multichannel high-speed data links.

This object is achieved by a method for high-speed data transfer in a digital mobile communication system, the method comprising the steps of establishing a non-transparent data connection having a number of parallel subchannels allocated on the radio interface, said number being determined by a specific maximum transfer capacity; receiving user data from a terminal interface at a varying user data rate; transmitting user data over the non-transparent data connection in data frames by employing a communication protocol which acknowledges data frames received correctly and retransmits defective data frames; buffering data frames to be transmitted in a transmission buffer; storing the data frame transmitted in the transmission buffer for a possible retransmission until an acknowledgement is received from the receiving end. The method is characterized by determining the actual user data rate on the terminal interface; determining a minimum number of subchannels, said number being determined by the actual user data rate; transmitting user data in data frames only via specific subchannels corresponding in number to said minimum number of subchannels; interrupting transmission or activating discontinuous transmission on each surplus subchannel allocated to the connection; monitoring fill level of the transmission buffer; continuing transmission or deactivating discontinuous transmission on at least one of said surplus subchannels if the transmission buffer fill level reaches a first threshold value; interrupting transmission or reactivating discontinuous transmission on at least one of said surplus subchannels if the transmission buffer fill level decreases to a second threshold level.

The basic concept of the present invention is to transmit frames of the radio link protocol (RLP) selectively only via specific subchannels in cases the maximum data transfer capacity allocated to the data link

is not required. This is important because interleaving on the radio interface spreads an RLP frame over several TDMA frames. If the RLP frames were transmitted over arbitrarily selected subchannels without any consistency, many or maybe all allocated subchannels would constantly be "active". According to the present invention, transmissions are concentrated on specific subchannels only, whereas the other subchannels allocated to the connection carry no transmission at all, or they employ subchannel-specific DTX. The direct benefits of a lower number of active subchannels include reduced transmitter power consumption, less temperature problems and a simpler timing of reception, transmission, and measuring neighbouring cells. In addition, as the number of unnecessary transmissions on the radio interface is lower, the interference level in the mobile communication network will be lower.

The required minimum number of subchannels can be determined by monitoring the data flow into the transmission buffer, i.e. the actual user data rate. Furthermore, by monitoring the amount of buffered data it is possible to determine whether more active subchannels will be required than said minimum number, and to dynamically increase and decrease the number of subchannels in use. Data amount mentioned above can be represented e.g. data rate, buffer status, number of PDUs or RLP frames etc. Determining the number of subchannels used, and weightings for different subchannels may be based on various mathematical and statistical variables of the amount of input and buffered data, such variables being for example instantaneous value, a fixed average, a moving average, or some other statistical variable (geometric mean, median, etc). This allows the control process to react in a controlled fashion to sudden, slow, temporary or long term changes in the transmission



capacity requirements and availability. Such changes may be caused by, for example, handover, bad coverage (temporary or long term), a data transfer request, requested retransmission of corrupted data, allocation of  
5 new subchannels to the connection, removal of subchannels from the connection, and changes in the radio interface channel coding.

There are different ways to choose the subchannels on which data transfer will be continued. One of the  
10 embodiments of the invention utilizes a subchannel preference list which organizes the subchannels according to principles such as: (1) an order based on the position of subchannels in a TDMA frame, (2) a predetermined order which depends on the total number of subchannels on the  
15 connection, (3) an order to be negotiated during the connection, or (4) an arbitrary order. Even an arbitrary order is advantageous if maintained the same for the duration of several TDMA frames.

#### **Brief Description of the Drawings**

20 In the following the invention will be described in greater detail by means of the preferred embodiments, with reference to the accompanying drawings, in which

Figure 1 illustrates a part of a mobile communication system to which the present invention can be  
25 applied on a single channel non-transparent connection,

Figure 2 is a block diagram illustrating the functional units of a single channel non-transparent GSM traffic channel on different protocol levels,

Figure 3 shows a L2R PDU,

30 Figure 4 shows an RLP frame,

Figure 5 illustrates a part of a GSM mobile communication system to which the invention can be applied on a multichannel non-transparent connection,

35 Figure 6 is a block diagram illustration of an arrangement for an HSCSD connection in accordance with the

invention.

#### **Preferred Embodiments of the Invention**

The present invention can be applied to a high-speed data transmission in digital mobile communication systems utilizing various multiple access methods, such as TDMA or CDMA. In different multiple access methods the physical concept of traffic channel varies, being primarily defined by a time slot in TDMA systems, a spreading code in CDMA systems, a radio channel in FDMA systems, a combination thereof, etc. The basic concept of the present invention is, however, independent of the type of the traffic channel and the multiple access method used.

The present invention can be used in all digital data transfer systems on a non-transparent data link comprising several parallel subchannels (e.g. multi-slot access).

The present invention is particularly well suited to data transfer applications in digital TDMA mobile communication systems, such as the Pan-European digital mobile communication system GSM, DCS1800 (Digital Communication System), a mobile communication system according to the EIA/TIA Interim Standard IS/41.3, etc. Below, the invention will be described by using the GSM system as an example but without restricting the invention to it. Figure 1 very briefly shows the basic structure of the GSM system, not paying closer attention to its characteristics or other aspects of the system. For a more detailed description of the GSM system, the GSM recommendations and "The GSM System for Mobile Communications", M. Mouly & M. Pautet, Palaiseau, France, 1992, ISBN:2-9507190-0-7, are referred to.

A mobile services switching centre MSC handles the connecting of incoming and outgoing calls. It performs functions similar to those of an exchange of a public

switched telephone network (PSTN). In addition to these, it also performs functions characteristic of mobile communications only, such as subscriber location management, jointly with the subscriber registers (not shown) of the network. The mobile stations MS are connected to the center MSC by base station systems BSS. The base station system BSS consists of a base station controller BSC and base stations BTS.

The GSM system is a time division multiple access (TDMA) system in which time-division traffic takes place on the radio path in successive TDMA frames each of which consists of several time slots. In each time slot, a short information packet is sent as a radio frequency burst which has a finite duration and which consists of a set of modulated bits. The time slots are mainly used for transmitting control channels and traffic channels. On the traffic channels, speech and data are transmitted. On the control channels, signalling between a base station and mobile subscriber stations is carried out. Channel structures used on the radio interface of the GSM system are defined in closer detail in the GSM recommendation 05.02. In operating according to the recommendation, at the beginning of a call a mobile station MS is assigned a time slot from a carrier wave as a traffic channel (Single Slot Access). The MS synchronizes to this time slot to transmit and receive radio frequency bursts.

In the GSM system, a data link is established between a mobile station MS network terminal TAF (Terminal Adaptation Function) 31 and a network adaptor IWF (Interworking Function) 41 in the fixed network (usually at the MSC). The data link is a circuit-switched connection which reserves one (or more) traffic channel(s) from the radio interface for the duration of the connection. In the GSM network, the data link in data transfer is a V.110 rate adapted, V.24 interface

compatible, UDI coded digital Full Duplex connection. The V.110 connection is originally a digital transmission channel developed for ISDN (Integrated Services Digital Network), specified in the recommendation CCITT Blue Book V.110. The terminal adaptor TAF adapts a data terminal TE connected to the MS for the V.110 connection which in Figure 1 is established over a circuit-switched connection using traffic channel ch0. The network adaptor IWF adapts the V.110 connection to another V.110 network such as an ISDN or another GSM network, or to another transit network, e.g. the public switched telephone network PSTN.

In addition, the traffic channel employs channel coding FEC (Forward Error Correction) with the aim of reducing the effect of transmission errors on the radio path. The GSM system employs convolution coding according to the GSM recommendation 05.03, the efficiency of which can be illustrated by a convolution coding ratio  $X/Y$ , which signifies that  $X$  data bits are represented in the channel coding by  $Y$  code bits. On a full-rate GSM traffic channel, on user data rates 9.6 kbit/s, 4.8 kbit/s and 2.4, the convolution coding ratios of  $1/2$  (punctured),  $1/3$  and  $1/6$ , respectively, are employed.

The circuit-switched non-transparent connection between the TAF and the IWF on a GSM traffic channel comprises several protocol layers.

The terminal interface between the MS terminal adaptor TAF and the data terminal equipment, as well as the interface between the IWF and e.g. an audio modem MODEM are in accordance with CCITT V.24, and in Figure 2 the terminal interface is marked with the symbol L2. As far as the invention is concerned, the interesting protocols are L2R (Layer 2 Relay) and RLP (Radio Link Protocol) which both are at the terminal adaptor TAF and the network adaptor IWF at both ends of the connection. In addition, the connection has, as illustrated in Figure 2,

different kinds of Rate Adaptation (RA) functions, such as RA1' between the TAF and a CCU unit (Channel Codec Unit) located at the BSS, RA1 between the CCU and the IWF, RAA between the CCU and a transcoder unit TRAU placed apart from the base station, and RA2 between the TRAU and the IWF. The rate adaptation RA functions are defined in the GSM recommendations 04.21 and 08.20. Communication between the CCU and the TRAU is defined in the GSM recommendation 08.60.

The information rate-adapted on the radio interface RA1' is furthermore channel-coded the way specified in the GSM recommendation 5.03, illustrated by blocks FEC in the MS and CCU.

The present invention, however, only relates to the L2R/RLP operation of the TAF and the IWF, and communication between them. The other aforementioned lower layer protocols, functions and units only provide a transmission path according to the GSM recommendations between L2R/RLP units, and they are not significant to the present invention with the exception of channel coding FEC. Consequently, the other functions are not described herein in any greater detail.

L2R (Layer 2 Relaying) functionality for non-transparent character-oriented protocols is defined e.g. in the GSM recommendation 07.02. L2R packs the user data and the status information originating from the terminal interface into 200-bit, 25-octet long PDUs (Protocol Data Units), such as the one illustrated in Figure 3. The octets are numbered 0-24, octet 0 being transmitted first. The bits in the octets are numbered 1-8, bit 1 being transmitted first. In a PDU, the octet may be a status octet, a character (higher layer data) or fill bits. Octet 0 is always a status octet. A status octet comprises 3 bits, SA, SB and X for the status of the V.24 connection, and 5 bits that indicate the number of data octets

succeeding the status octet, as well as the special indications of the data octets such as empty and PDU. In Figure 3, status octet 0 is succeeded by 3 data octets into which the word "GSM" has been packed, after which a new status octet 4 follows.

The L2R PDUs are packed in a frame according to the RLP protocol, such a frame being shown in Figure 4. The RLP protocol is specified in the GSM recommendation 04.22. The RLP is a balanced (HDLC type of) data transfer protocol with a frame structure, in which error correction is based on retransmitting corrupted frames at the request of the receiving party. The RLP extends from the mobile station MS terminal adaptor TAF to the network adaptor IWF, which is usually located at the MSC. As shown by Figure 4, the RLP frame structure comprises a header field (16 bits), an information field (200 bits), and a frame check sequence (24 bits). The 200-bit L2R PDU is packed in the information field. As a result, the net RLP data rate is clearly above the maximum 9.6 kbit/s data rate for one channel, which allows a specific number of retransmissions without a decline in the nominal user rate. For example, if the user rate on the terminal interface is 9600 bit/s and the data rate on the radio interface is 12 kbit/s, the "surplus capacity" is, depending on the character structure being used, at least 12.5%.

The transmission buffer buffers the data received from the V.24 interface so that data will not be lost even if the MS is not able to transmit it instantly over the radio interface. A reception buffer buffers data which is transferred to the V.24 interface so that data received from a traffic channel will not be lost even if it cannot immediately be forwarded via the V.24 interface to e.g. the terminal equipment TE. The RLP protocol also includes a flow control, used to adjust the fill level of the transmission and reception buffers. The flow control is

specified in the GSM recommendation 07.02. The criterion used to activate the flow control may be a half full transmission or reception buffer.

5 The maximum user data rate on a single GSM traffic channel is restricted to 9.6 kbit/s.

10 In high-speed data services (HSCSD), several traffic channels are assigned to a data call; in other words, two or more time slots are assigned from the same TDMA frame. An example of how to carry out high-speed data transfer based on a multitude of traffic channels is disclosed in the applicant's co-pending PCT application WO95/31878 and WO96/18248. However, it should be noted that as far as the invention is concerned, the only significant matter is that a multichannel data link can be  
15 established.

Figure 5 illustrates a GSM network architecture implementing such a data transfer on several parallel traffic channels. Figure 5 is similar to Figure 1, with the exception that in Figure 5 there is, between the TAF  
20 and IWF, a circuit-switched non-transparent connection which consists of N parallel traffic channels ch0-chn, where  $N=1,2,3,\dots$ . In the mobile station, the TAF functions as a divider which splits the high-speed data signal DATA IN originating from the data terminal  
25 equipment into parallel traffic channels ch0-chn, and a combiner which combines the subsignals received from the parallel traffic channels ch0-chn back into a high-speed data signal DATA OUT. Correspondingly at the other end of the multichannel data link, the IWF functions as a divider  
30 which splits the input high-speed data signal DATA IN into parallel traffic channels ch0-chn, and a combiner which combines the subsignals received from the parallel traffic channels ch0-chn back into a high-speed data signal DATA OUT.

35 The protocol structure of Figure 2 may also be

applied to the Figure 5 multichannel connection architecture. In the preferred embodiment of the invention, the L2R/RLP unit is common to all the traffic channels allocated for the same connection. Out of these, the RLP at the same time functions as the aforementioned divider and combiner. However, each traffic channel is provided with a dedicated rate adaptation (RA) and channel coding (FEC) functions, as illustrated by Figure 2. Thus, from the view point of the L2R/RLP unit, the multichannel data link is substantially similar to a single channel link; the "transmission channel" between them only has more capacity than before.

The HSCSD connection can also be illustrated by the block diagram of Figure 6, in which the L2R and RLP protocol functions are distributed into separate units 62 and 63 in the TAF/MS and correspondingly into units 64 and 65 in the IWF/MS at the receiving end. Unit L2R packs the data in the L2R PDUs as described above. However, in the HSCSD slightly modified PDUs are employed; the number of bits in the PDUs is smaller, i.e. 192. The reason for this is to compensate for the reducing user data rate in the RLP protocol, the reduction being caused by the extra overhead information required by the HSCSD in the RLP frames. As to the present invention, the difference caused by the HSCSD in the PDUs and the RLP frames is not relevant and will not be described here in closer detail. The terms PDU and RLP in this application are used to refer to all the versions.

L2R unit 62 outputs the PDUs to RLP unit 63. RLP unit 63 inserts the PDUs in RLP frames and splits them in subchannels  $chl-chn$ , where  $n$  is an integer and  $\geq 2$ . A radio transceiver TRx carries out for each subchannel (following rate adaptation and channel coding) building of bursts, interleaving and modulation, and transmission over the radio interface in a corresponding subchannel time



slot. The BTS radio transceiver TRx receives the bursts in the subchannel time slots, and carries out deinterleaving separately for each subchannel, and (following channel decoding) forwards the RLP frames of each subchannel chl-chn to RLP unit 64 which combines the PDUs and feeds them to L2R unit 65. Between the BTS and IWF, the RLP frames have to be transferred in TRAU frames but this is not significant to the present invention.

When the user data rate in a HSCSD service substantially corresponds with the maximum capacity allocated to the connection, full PDUs are transmitted on all subchannels. If, as noted earlier, the user data rate in a HSCSD service is lower than the maximum capacity of the radio link protocol, L2R unit 62 may build partially filled PDUs and transmit them over the radio interface subchannels in RLP frames. Conventionally, however, the transmission has been distributed arbitrarily on all the subchannels ch0-chn, with the result that all the subchannels are more or less active.

According to the present invention, RLP unit 63 uses for transmitting RLP frames only a specific portion of the subchannels chl-chn in cases the maximum data transfer capacity allocated to the connection is not required. On the other, unused subchannels, there is no transmission present at all, or they have a channel-specific DTX. The minimum number of subchannels used is defined according to the actual data user rate into the L2R unit, and the need for any additional channels is defined according to the buffered data amount. This will be described in the exemplary embodiment below with reference to Figure 6.

The amount of input data, and the fill level of the buffers in the L2R unit 62 and RLP unit 63 are monitored by a DTX control unit 61. At first, it is assumed that the maximum transfer capacity allocated to a data call is

three traffic channels, i.e.  $3 \times 9.6 \text{ kbit/s} = 28.8 \text{ kbit/s}$ . DTX control 61 monitors the actual user data rate of the data flow into L2R unit 62. If the average user data rate exceeds the capacity of two subchannels, i.e. 19200 kbit/s, the minimum capacity required will be three subchannels, i.e. the same as the maximum capacity allocated to the data link. If that is the case, DTX control 61 directs RLP unit 63 to transmit in the normal manner on all three subchannels.

It is further assumed that the average user data rate into L2R unit 62 drops during the call to a value lower than 19.2 kbit/s, e.g. 18 kbit/s. DTX control 61 defines a minimum number of traffic channels for the aforementioned average user data rate of 18 kbit/s, i.e. two subchannels. DTX control unit 61 thereby directs RLP unit 63 to actively transmit on only two subchannels, for example on subchannels ch1 and ch2. Transmission on the third subchannel ch3 will be temporarily interrupted or discontinuous transmission DTX according to the GSM specifications will be activated on it. In such a case, RLP unit 63 transmits, to the subchannel ch3, L2 fill frames according to the GSM recommendation 04.06, item 5.4.2.3. The TRX receives these RLP frames from RLP unit 63, but only forwards them onto the radio path in specific TDMA frame subgroups, specified in the GSM recommendation 05.08, item 8.3. At other times, the subchannel has no transmission in the DTX mode.

DTX control 61 continues to monitor the average user data rate, and simultaneously monitors at least the fill level of the RLP unit 63 buffer. The RLP buffer contains both the RLP frames to be transmitted for the first time and RLP frames already transmitted to which no acknowledgement has yet been received from the receiving end. DTX control 61 may have e.g. two threshold values for the buffer fill level. When the fill level of the RLP

buffer is below a specific threshold value, DTX control 61 considers the present number of subchannels to be adequate. If the buffer fills to this threshold value, DTX control 61 considers the present number of subchannels to be inadequate for data transmission. This leads to DTX control 61 deactivating DTX from subchannel ch3. RLP unit 63 begins to transmit user data in RLP frames on subchannel ch3, too, even though the minimum capacity corresponding to the average user data rate of 18 kbit/s is two subchannels. As a result, the RLP unit 63 buffer begins to empty. As soon as the buffer empties down to the lower predetermined threshold value, DTX control 61 considers the minimum capacity corresponding to the average user data rate, i.e. two subchannels, to be adequate for transmission. Consequently, DTX control 61 reactivates DTX on subchannel ch3. RLP unit 63 recommences transmitting RLP frames containing user data only via subchannels ch1 and ch2. Via subchannel ch3, fill frames are transmitted.

If the average user data rate drops to lower than 9.6 kbit/s, the minimum capacity required is one subchannel. In such a case, the DTX mode will also be activated e.g. on subchannel ch2, and user data is only transmitted on subchannel ch1. DTX control 61 continuously monitors the buffer fill level of RLP unit 63, and if necessary deactivates DTX from one or more subchannels.

If the average user data rate again gains a value higher than 19.2 kbit/s, DTX control 61 again takes all the allocated subchannels ch1-ch3 in normal use.

Alternatively, the fill level of the buffer in RLP unit 63 may have several threshold values in both directions. Upon filling of the buffer to a specific threshold value, DTX is deactivated from one or more subchannels; upon reaching the next threshold value, DTX is again deactivated from one or more subchannels, etc. In

a similar manner, as the buffer empties to a threshold value, DTX is reactivated on one or more subchannels; as the next threshold values is reached, DTX is again activated on one or more subchannels, etc.

5           At the receiving end, the BTS and the IWF operate as normal, receiving on all subchannels. DTX on specific subchannels is dealt with according to the GSM recommendations.

10           The invention is most advantageous when applied to a MS transmission. The method is also applicable when transmitting from the mobile communication network to the mobile station, whereby the radio interference level in the mobile communication network will be lower.

15           As noted above, for determining the user data rate and monitoring the buffer fill level, different kind of statistical methods can be applied. Also, as noted above, the traffic channels to be used at any one time may be selected according to a specific preference list.

20           The figures and the explanation related thereto are only intended to illustrate the present invention. The method of the invention may vary in its details within the scope of the attached claims.

## Claims

1. A method for high-speed data transfer in a digital mobile communication system, the method comprising
- 5 the steps of
- establishing a non-transparent data connection having a number of parallel subchannels allocated on the radio interface, said number being determined by a specific maximum transfer capacity;
- 10 receiving user data from a terminal interface at a varying user data rate;
- transmitting user data over the non-transparent data connection in data frames by employing a communication protocol which acknowledges data frames received correctly and retransmits defective data frames;
- 15 buffering data frames to be transmitted in a transmission buffer;
- storing the data frame transmitted in the transmission buffer for a possible retransmission until an acknowledgement is received from the receiving end,
- 20 c h a r a c t e r i z e d by
- determining the actual user data rate on the terminal interface;
- determining a minimum number of subchannels, said
- 25 number being determined by the actual user data rate;
- transmitting user data in data frames only via specific subchannels corresponding in number to said minimum number of subchannels;
- interrupting transmission or activating
- 30 discontinuous transmission on each surplus subchannel allocated to the connection;
- monitoring fill level of the transmission buffer;
- continuing transmission or deactivating discontinuous transmission on at least one of said surplus
- 35 subchannels if the transmission buffer fill level reaches

a first threshold value; and

interrupting transmission or reactivating discontinuous transmission on at least one of said surplus subchannels if the transmission buffer fill level decreases to a second threshold level.

5

2. A method as claimed in claim 1, characterized by the steps of:

determining a minimum number of subchannels, said number being determined by the actual user data rate,

10

transmitting user data in data frames via specific subchannels the number of which at least equals said minimum number of subchannels, and

changing dynamically the number of said allocated subchannels according to the fill level of the transmission buffer.

15

3. A method as claimed in claim 2, characterized in that the dynamic changing of the number of specific subchannels comprises the steps of:

continuing transmission or deactivating discontinuous transmission on said at least one of the other subchannels, if the transmission buffer fill level reaches a first threshold value, and

20

interrupting transmission or reactivating discontinuous transmission on said at least one of the other subchannels, if the transmission buffer fill level decreases to a second threshold value.

25

4. A method as claimed in claim 1, 2 or 3, characterized by the step of:

transmitting user data via all the allocated subchannels if said minimum number of subchannels matches the number of subchannels allocated for the data connection.

30

5. A digital mobile communication system comprising a transmitting party (MS, TAF) having a transmission buffer (63);

35

a receiving party (IWF);

a multichannel non-transparent circuit-switched data connection between the two parties, said multichannel data connection having parallel subchannels allocated on a radio interface, the number of said allocated subchannels  
5 being determined by a specific maximum transfer capacity;

a communication protocol (RLP) in which data is transferred over said data connection in data frames so that data frames received correctly are acknowledged and defective data frames received are retransmitted, said  
10 transmission buffer buffering the data frames to be transmitted and storing the transmitted data frames until it receives an acknowledgement of successful reception,

15 c h a r a c t e r i z e d by

the transmitting party (MS) being arranged to monitor the actual user data rate and the fill level of the transmission buffer, and by

the transmitting party (MS) being arranged to transmit user data in data frames via specific allocated  
20 subchannels, the number of said allocated subchannels depending on the actual user data rate and the fill level of the buffer, and to interrupt transmission or to activate discontinuous transmission on possible other  
25 allocated subchannels.

6. A system as claimed in claim 5, c h a r a c t e r i z e d in that the transmitting party is a terminal adapter (TAF) of the mobile station (MS), and the receiving party is a network adaptor (IWF) of the  
30 mobile communication network.

7. A system as claimed in claim 5, c h a r a c t e r i z e d in that the transmitting party is a network adaptor (IWF) of the mobile communication network, and the receiving party is a terminal adaptor  
35 (TAF) of the mobile station.

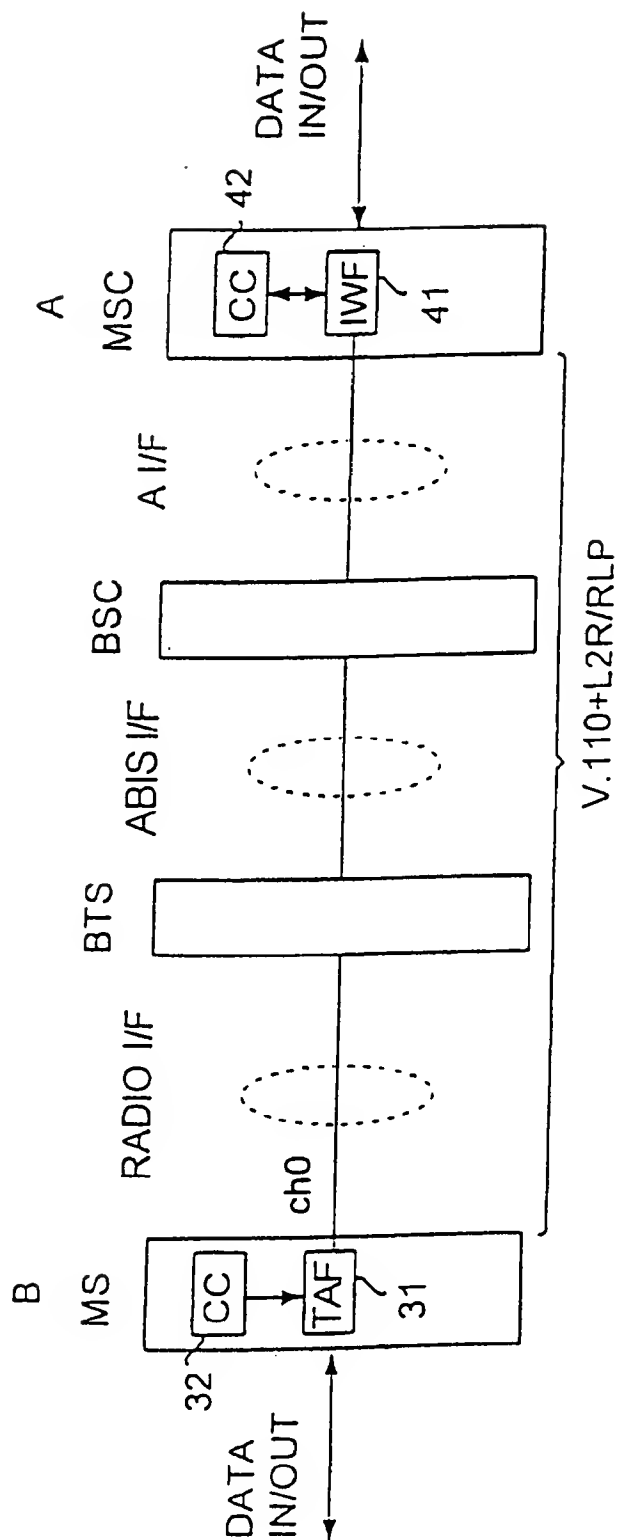


FIG. 1



**RADIO  
INTERFACE**

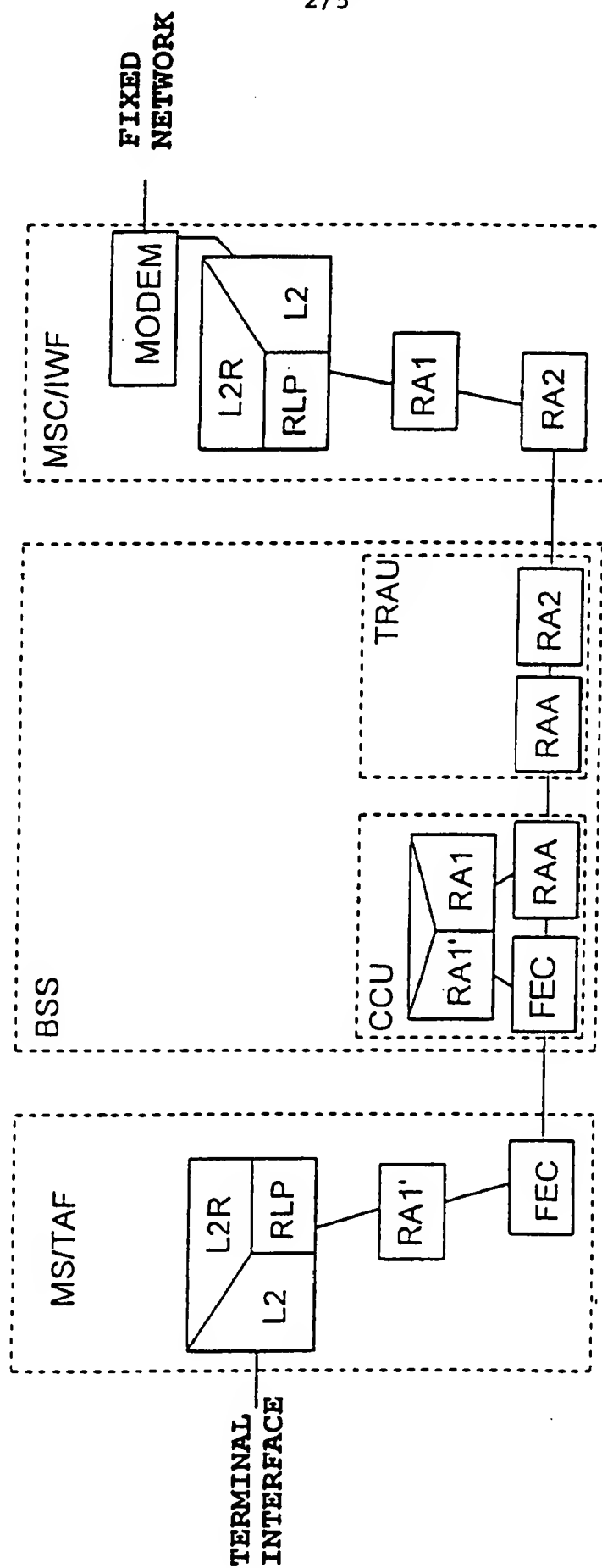


FIG.2

3/5

	8	7	6	5	4	3	2	1	
0	SA	SB	X	0	0	0	1	1	
1	1	1	0	0	0	1	1	1	IA5 "G"
2	1	1	0	1	0	0	1	1	IA5 "S"
3	1	1	0	0	1	1	0	1	IA5 "M"
4	SA	SB	X	1	1	1	1	1	
n									

FIG. 3



FIG. 4

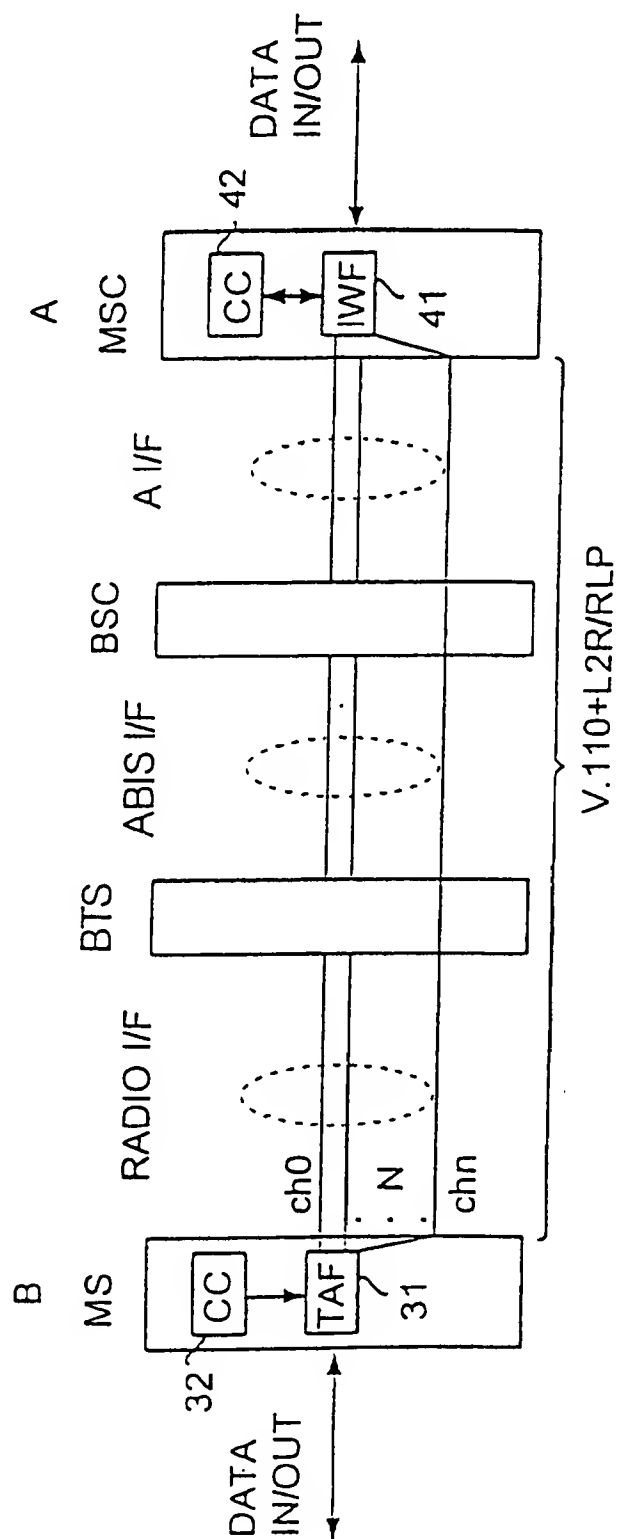


FIG. 5

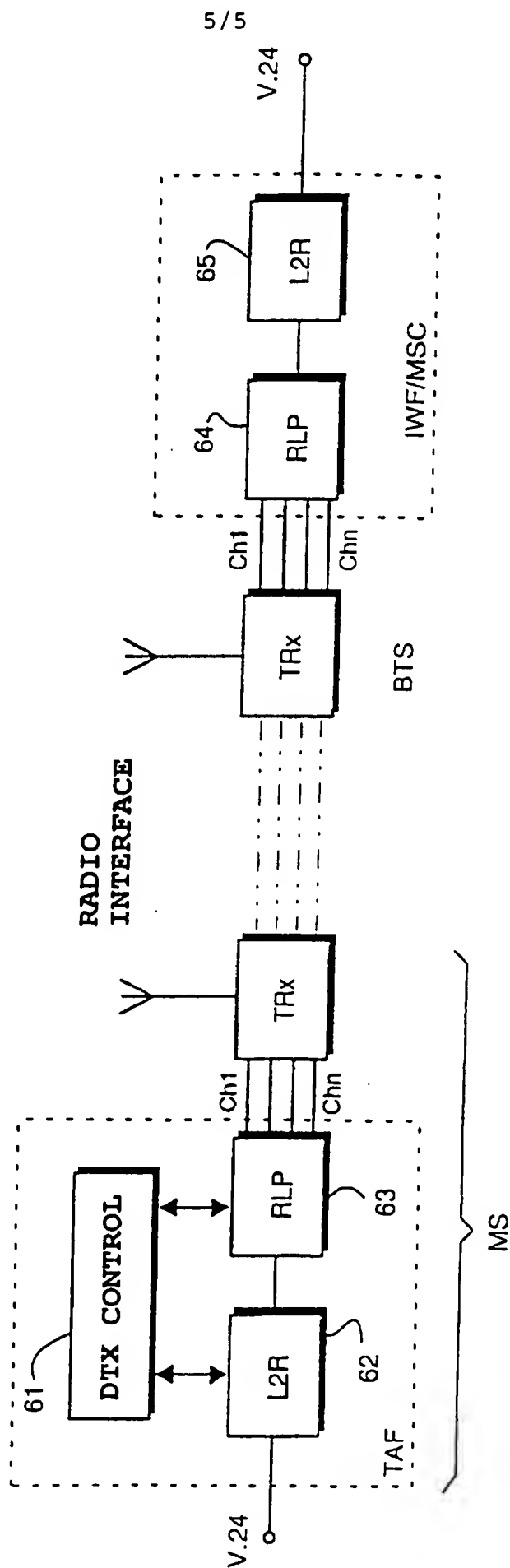


Fig. 6

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 96/00669

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04J 3/16

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04Q, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	WO 9636146 A1 (NOKIA TELECOMMUNICATIONS OY), 14 November 1996 (14.11.96), page 4, line 23 - page 6, line 14; page 9, line 19 - page 10, line 15; page 11, line 26 - page 12, line 25, abstract  --	1,5-7
A,P	WO 9627959 A1 (NOKIA TELECOMMUNICATIONS OY), 12 Sept 1996 (12.09.96), page 3, line 33 - page 7, line 3, abstract  --	1-5
A,P	WO 9609708 A2 (NOKIA MOBILE PHONES LTD.), 28 March 1996 (28.03.96), page 1, line 4 - page 3, line 17, abstract  --	1,5

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

<ul style="list-style-type: none"> <li>* Special categories of cited documents</li> <li>"A" document defining the general state of the art which is not considered to be of particular relevance</li> <li>"B" earlier document but published on or after the international filing date</li> <li>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</li> <li>"O" document referring to an oral disclosure, use, exhibition or other means</li> <li>"P" document published prior to the international filing date but later than the priority date claimed</li> </ul>	<ul style="list-style-type: none"> <li>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</li> <li>"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</li> <li>"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</li> <li>"&amp;" document member of the same patent family</li> </ul>
--	--

Date of the actual completion of the international search

26 May 1997

Date of mailing of the international search report

29-05-1997

Name and mailing address of the ISA/  
Swedish Patent Office  
Box 5055, S-102 42 STOCKHOLM  
Facsimile No. +46 8 666 02 86

Authorized officer

Peter Hedman  
Telephone No. +46 8 782 25 00

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 96/00669

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9501032 A1 (QUALCOMM INCORPORATED), 5 January 1995 (05.01.95), abstract  -- -----	1,5

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.  
PCT/FI 96/00669

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9636146 A1	14/11/96	AU 5650596 A EP 0770294 A FI 97927 B,C FI 952253 D	29/11/96 02/05/97 29/11/96 00/00/00
WO 9627959 A1	12/09/96	AU 4833296 A FI 951019 A	23/09/96 07/09/96
WO 9609708 A2	28/03/96	AU 3389695 A FI 944352 A	09/04/96 21/03/96
WO 9501032 A1	05/01/95	AU 7113694 A BR 9406891 A CN 1108834 A EP 0705512 A FI 956091 A IL 109842 D JP 9501548 T US 5566206 A ZA 9404032 A	17/01/95 26/03/96 20/09/95 10/04/96 16/02/96 00/00/00 10/02/97 15/10/96 09/03/95